DEVELOPMENT OF CONTROL SYSTEM FOR AUTOMATED GUIDED VEHICLE (AGV)

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ABSTRACT

This thesis is focused on development of the control system for Automated Guided Vehicle (AGV). This thesis concentrates on developing the control system for AGV involve about how the AGV will operate, involve of the movement and loading & unloading mechanism. The objectives of this project are to develop the control system parts involving develop the electronic circuit system and computer program of the system. The wired guided navigation used to communicate the computer to the AGV to ensure the AGV work accordingly. Subsequently, this project needs to be fabricating each of the electronic components to become one complete circuit. All the computer programmings are building by using Code Blocks software, the compiler which is compatible with electronic components and Visual Basic software. Afterwards, Visual Basic 6 is used in this project to create user friendly interface which is better than C interface (Command Prompt). This thesis also includes the test result of control system involving test program and test circuit for the AGV before proceed to the real AGV control system.

ABSTRAK

Tesis ini memfokuskan tentang pembangunan sistem kawalan Kenderaan Panduan Automatik atau *Automated Guided Vehicle* (AGV). Tesis ini menumpukan tentang pembangunan system kawalan untuk AGV melibatkan bagaimana AGV ini beroperasi, melibatkan pergerakan dan mekanisma mengangkat dan menurunkan barang. Objektif projek ini ialah untuk membangunkan bahagian system kawalan melibatkan pembangunan litar elektronik dan system program computer. Konsep panduan wayar untuk kawalan digunakan untuk memastikan AGV ini beroperasi mengikut arahan yang betul dan tepat. Di samping itu, projek ini memerlukan pemasangan untuk setiap komponen elektronik untuk membentuk sebuah litar yang lengkap. Semua program computer untuk kawalan menggunakan perisian Code Block, perisian yang sesuai digunakan untuk komponen elektronik dan perisian Visual Basic.Tambahan, perisian Visual Basic 6 digunakan di dalam projek ini untuk membuat antara muka yang lebih mesra pengguna berbanding dengan menggunakan antara muka C. Tesis ini juga merangkumi keputusan ujian yang telah di jalankan melibatkan keputusan percubaan pertama dan litar ujian untuk AGV sebelum diteruskan kepada keputusan system kawalan AGV yang sebenar.

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LIST OF SYMBOL

V_{ss}	Logic Supply Voltage
V_s	Power Supply Voltage
V_{ref}	Voltage Reference
V_{en}	Enable Voltage
V_i	Voltage Input
R_{SA}	External Resistor A
R_{SB}	External Resistor B
P_1	Input 1
P_2	Input 2
P_3	Input 3
M	Motor
I_o	Peak Output Current

LIST OF ABBREVIATIONS

AGV	Automated Guided Vehicle
MHE	Material Handling Equipment
MSDS	Material Safety Data Sheet
VB	Visual Basic
JIT	Just In Time
AS	Automatic Storage
RS	Retrieval System
IC	Integrated Circuit
AI	Artificial Intelligent
GND	Ground
CW	Clockwise
CCW	Counter-Clockwise

CHAPTER 1

INTRODUCTION

1.1 Project Background

This project is about to create and develop the Automated Guided Vehicle (AGV) based on three main parts which are design & prototype of AGV, development of control system for AGV and design & prototype of loading & unloading mechanism for AGV. This project involves of parts from sketching, drawing, measuring each dimension to the control system part which involves computing wiring system and software application and also the mechanism of loading & unloading system to ensure the AGV can run perfectly.

1.2 Automated Guided Vehicle (AGV)

AGV is one type of Material Handling Equipment (MHE) like conveyors, cranes & hoists, elevator & lifts, automatic storage & retrieval system and so on which are focuses on process of transferring something from one place to another places especially in industrial sector or industrial warehouse. Actually, the goals to maintain or improve product quality, reduce damage and provide protection of materials, promote safety and improve working condition, promote productivity, control inventory and so on.

For further information, AGV is a driverless vehicle capable of moving along predetermined paths and performing certain prescribed duties. Moreover, it's relatively non intelligent which can go where they are sent and perform very limited and simple activities.

Principally, the project is divided into major three areas as follows:

I. **Design and prototype of AGV**
–Designing the AGV model then from selecting material process until fabricating process.

II. **Development of Control System for AGV**
–Developing the control system involving wiring system and programming data as a command to run the AGV

III. **Design and prototype of Loading Unloading Mechanism for AGV**
– Designing the loading and unloading parts and also planning the loading and unloading mechanism.

1.3 Problem Statement

This AGV is designed to operate in the isolated room in UMP FKM lab. Currently, the FKM laser cutting machine has located inside the room (**Figure 1.1**). The principle of laser cutting is to cut materials by melting. Therefore, when cutting an Acrylic using laser, it also will melt the Acrylic and produce fume that contain hazardous substances which can give bad effect to human health. According to the Material Safety Data Sheet (MSDS) of Acrylic, when this fume is being continuously exposed to human, it will cause irritation to skin, eye and respiratory system.

Figure 1.1: Laser Cutting Machine Room

1.4 Objectives

I. To develop the control system for Automated Guided Vehicle (AGV).
II. To develop AGV circuit and wiring system.
III. To test the overall AGV system

1.5 Scope of Project

This project based on the application of the AGV control system where the flow of how the AGV will operate (movement and loading & unloading activities). To operate this AGV, there are consisting of two main parts which must achieve perfectly to ensure the AGV can work well. The first part is the AGV wiring system and the second part is the command software to guide the AGV movement and loading & unloading activities. Figure 1 below showed how the AGV is working.

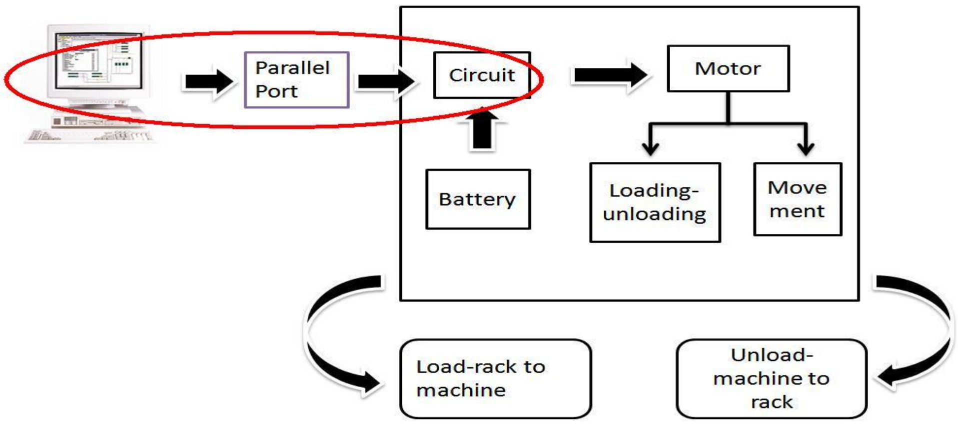

Figure 1.2: AGV working flow

The control systems are divided by 2 parts which are:

I. Wiring system

a) Create the wiring system which involving electric and electronic components to ensure the AGV are working accordingly.

b) To transfer control system from computer to the on-board driver by using parallel port.

II. Software application

There are two different soft ware that being used which are:

a) Code Blocks

- To create the body program of the whole operation.
- To control the tires movement and loading & unloading activities
- Code Blocks can be integrated with VB

b) Visual Basic (VB) 6.0

- To obtain user friendly interface.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to give the overview information about the Automated Guided Vehicle (AGV) which is part of the Material Handling Equipment (MHE) in the subject of its control system. In this chapter, the explanations and some of the MHE and the AGV control system histories, the previous research and findings, the theories are included. With reference from various sources as journal, thesis, references book, literature review has been carried out to collect information related to this project.

2.2 Material Handling Equipment-Automated Guided Vehicle

2.2.1 History of the Material Handling Equipment Technology

Material handling is defined by the Materials Handling Institute as the movement of bulk packaged and individual goods, as well as their in process and post process storage, by means of manual labor or machines within the boundaries of a facility. Although this field of study includes the handling of bulk (solid- or liquid-phase) material and individual goods, this chapter will only focus on the latter (i.e., ‘‘unit loads’’), with a primary emphasis on material handling equipment, as opposed to facility planning and movement control.

Material handling does not add value to the product but only cost. Thus the objective of material handling is the efficient movement of goods for the on-time delivery of correct parts in exact quantities to desired locations in order to minimize associated handling costs. It is not uncommon to have parts/subassemblies moving around a plant several kilometers prior to their shipment. Manufacturing plants must therefore eliminate all unnecessary part movements, as well as in process inventories, for just-in-time (JIT) production. Material handling equipment can be classified according to the movement mode: above-floor transportation (e.g., belt conveyors, trucks, etc.), on-floor transportation (e.g., chain conveyors), and overhead transportation (e.g., cranes). In the following sections, we will review industrial trucks (including automated guided vehicles), conveyors, and industrial robots as the primary mechanized/automated material handling equipment. We will also briefly review the automated storage and retrieval of goods in high density warehouses, as well as the important issue of automatic part identification (including bar codes). The chapter will be concluded with a discussion on automobile assembly.

2.2.2 Automated Guided Vehicle (AGV) System

Material handling is an important aspect of any production system. Material handling system have been prevalent since the beginning of mass production, either as manual system, mechanical system (forklifts, conveyors), or in more recent years as fully automated system (automated guided vehicle, (AGV), automatic storage and retrieval system (AS/ RS) etc). Technological advances and the need for flexibility and reliability have increased focused on automated material handling systems. The use of AS/RS and AGV systems are becoming commonplace in today’s industries. AGVs have become increasingly popular as a means of horizontal material handling transportation system. They are used wherever there is a need for an autonomous transportation system. AGVs are particularly useful where products need to be handled carefully or the environment is potentially dangerous to humans. Examples include handling of telecommunication products, IC chips, voltage cables and radioactive materials. In the automotive manufacturing industry, AGVs have been combined with robots to perform welding and painting operations.

2.2.3 Description of an AGV System

An AGV system is an advanced material handling system that involves one or more driverless vehicles each following a guide path and controlled by an off-board computer or microprocessor. AGV are typically used to carry unit loads in production and assembly operations. The advantages of AGVs include reliable, automatic operation, flexibility in adapting to changes in material flow, improved positioning accuracy, reduced handling damage, easily expandable layout and system capacity, and automated interfaces with other system. An AGV system allows automation of a certain portion of material handling and thereby, a reduction in the labor force. It also results in an increase in the efficiency of the material handling operation, resulting in better utilization of the work force and processing equipment. An AGV based material handling system also supports various tires of production systems and improves productivity.

The efficient material handling system also helps in reducing mistakes and improving quality. The improved system results in increased worker satisfaction as it is possible to change the material arrival rate to suit the workers pace. The main advantage that a discrete material handling system such as an AGV system offers is real-time control of material handling. This helps in identification of the parts, the routes they travel and the vehicles they travel in, resulting in a lower WIP inventory, reduced tardiness, lower inventory costs and better response to demands (Hammond (1986)). An AGV system also offers other benefits such as reduction in space requirements. Unlike conveyors or other material handling systems, AGVs are small in size and only move along the aisles. They minimize product damage and help in housekeeping. Changes in the layout and relocation of the material handling system are also much easier to accomplish when using AGVs. They also are combined with other existing material handling systems and offer flexibility.

The main disadvantage of an AGV based material handling system is its expense. The high cost of the control software used and the number of vehicles required in a system curtail the wide usage of AGVs as material handling systems. A trade-off analysis between the initial setup cost of an AGV system and the savings involved is necessary before installation. Other limitations of an AGV include necessity for polished floor surfaces for smooth operation of the AGVs, guide path bed stability problems and restrictions such as height of metal floors that must be crossed and weather conditions that it can operate under when used outside the manufacturing plant. Obstructions in the facility layout and ramp gradients are other obstacles that need to be overcome when designing the guide path for the AGVs. Other issues that need to be considered when installing an AGV system are management support, worker attitudes towards the new system, maintenance problems and requirements. It can be seen from above that though the AGV has a number of benefits it also has its share of disadvantages and may not be applicable in all cases.

2.2.4 Components of an AGV System

The different components of an AGV system are listed as below

1) **Vehicles** – The vehicle or the AGV consists of the frame, batteries, on-board charging unit, and electrical system, drive unit, steering, precision stop unit, communication unit, safety system and work platform. The components mentioned above can each be further classified into different categories based on their capabilities and features. The application for which the AGV is used dictates the type of component that is to be used.

2) **Guide path and guidance systems** – Most AGVs need a guide path to follow. The guide path techniques used are known as passive or active tracking. Passive tracking occurs when optical or metal detection principles (wireless) are used for vehicle guidance whereas active tracking involves inductive principles (for example, guide wire is used to help tracking).

3) **Floor and system controls** – The controller is the brain of the whole system, tying the vehicle and the guide path together and integrating the system. The AGVs contains three levels of control architecture: vehicle control system, floor control unit and vehicle on-board processor. These control systems take care of the different tasks such as lane selection, carrier selection, guide path frequency generation, blocking between vehicles, automatic routing, controlling speeds, displaying job information, monitoring floor equipment status, tracking loads and so on.

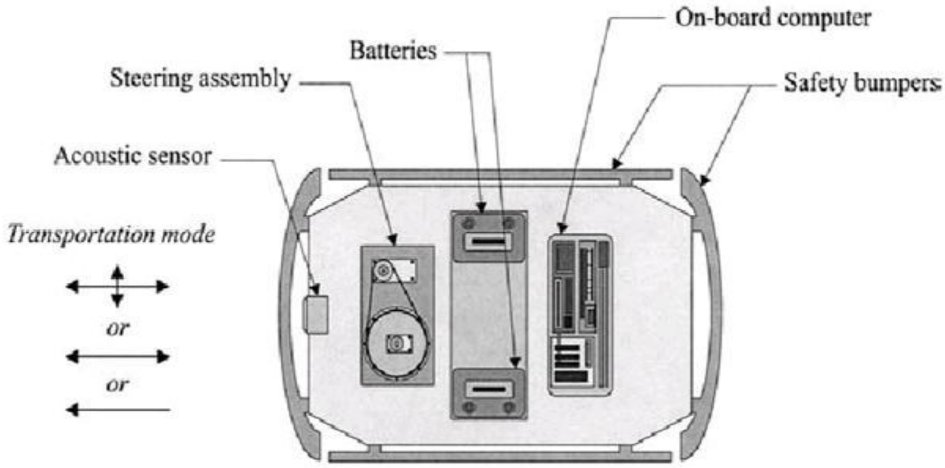

Figure 2.1: AGV Basic Components

Source: James M, 1977.

2.2.5 AGV System Design

The only current literature review on the Automated Guided Vehicle (AGV) flow path design problem is by Sinriech (1995). The general network design models for discrete material flow systems are reviewed. It concentrates more on the aspects of AGV flow path and reviewed individual papers very briefly. It also does not offer a classification scheme for the AGV flow path literature. However, the paper discusses various parameters involved in a material handling flow system and the different approaches that have been used to solve this problem. Peter, et al (1995) presents a control classification scheme for AGVs.

They present a nice classification scheme for an AGV system in general, but concentrate more on the control aspects of the problem. They present the classification scheme with three basic level namely – guide path determination, vehicle capacity and vehicle addressing mechanism.

The paper does not concentrate as much on each of the individual levels, but gives a brief overview of each level and sublevel. It presents a cubic structure (based on the levels and sub levels) which partitions the AGV system into 12 different classes. Depending on the functionality requirement and the sublevel chosen, this structure helps identify the relative complexity involved in designing the required AGV system.

Vosniakos and Mamalis (1990) discussed the issues involved in an AGV system design with respect to flexible manufacturing system applications. An overview of the different aspects of an AGV is presented with emphasis on route control and collision avoidance. Docking, load transfer, traffic control, communication between the controller and the vehicle, AGV management policies, evaluation of the control policies and various other aspects that have to be considered before setting up an AGV based system are also discussed.

One of the more important areas in an AGV design is the guide path and guidance system. The area of interest in the guidance system and guide path is the guide path layout. There has been little research in the area of guide path layout. The research done in area of guide path layout in AGV systems can be explained better using the classification scheme presented in Rajagopalan and Heragu (1997).

2.2.6 Flow Path Type

The type of flow path in an AGV system is its most important characteristic. The flow path for any AGV system dictates how the AGV will travel between the different pickup/drop-off (p/d) points. The classification is based on the type of flow path used.

2.2.6.1 Traditional Layout

Maxwell and Muckstadt (1982) first recognized the importance of AGV based material handling system design. They developed a model that determines the maximum number of AGVs needed to efficiently transfer material from one facility to another. The problem was solved assuming the guide path was already installed and the best route had to be determined. The objective under consideration was to minimize total travel time. Figure 2.1 shows a traditional AGV flow path design.

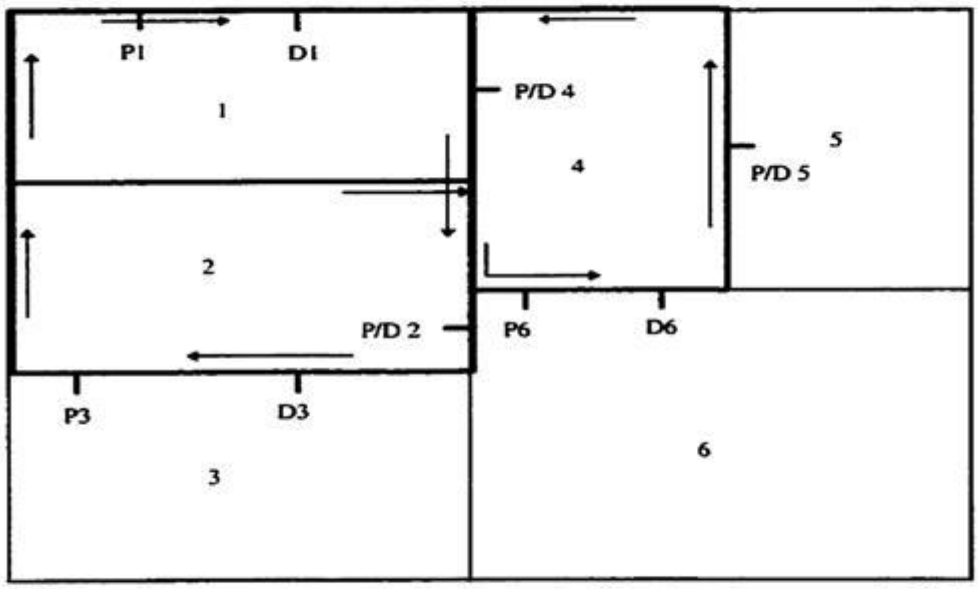

Figure 2.2: Traditional AGV flow path design

Source: James M, 1977.

Maxwell and Wilson (1981) had developed a dynamic network flow model earlier to analyze the effects of blocking in a fixed path system. A traditional flow path design involved determining the best path that connected all the given p/d points.

Gaskin and Tanchoco (1987) presented a binary integer model to determine the optimal flow path for an AGV system. They only considered the movement of loaded vehicles unlike Maxwell and Muckstadt (1982). They did not make any assumptions about the flow path except that movement was restricted to certain areas (such as the aisles), nor did they discuss any generic solution method to the model. An example is solved to illustrate the approach used, but this approach cannot be generalized.

Kaspi and Tanchoco (1990) considered a unidirectional AGV system and solved the optimal flow path design problem using a branch and bound technique. The formulation is the same as that presented by Gaskins and Tanchoco (1987). They formulate the problem as a graph network (node – arc network) with the pick-up/drop-off points as nodes and feasible guide paths as arcs. They also addressed the reach ability problem which tackles the situation where a group of nodes might end up as sink nodes.

Sinriech and Tanchoco (1991) developed a formulation to solve the traditional AGV flow path problem using a graph theory approach. They use the same node – arc formulation as Kaspi and Tanchoco (1990) and use the model to give directions to the undirected graph network. They then use an improved branch and bound technique to solve the problem. They consider both loaded and unloaded travel time in this formulation. Gaskins and Tanchoco (1989) developed a model to solve the virtual flow path problem. The virtual flow path arises in cases where the AGV guide path does not exist in reality. The AGV is guided by the controller without the need for a physical guide path.

They formulate the problem as a multi commodity flow problem where the material to be transferred is substituted for people and unit loads. This results in an integer model based on the multi-commodity flow problem. Instead of Euclidean or rectilinear distance, they consider a path distance which takes into account the fact that rectilinear distances and Euclidean distances may not always be applicable when considering distance between two facilities.

A path distance is the actual distance taken by an AGV to travel from one point to another. Goetz and Tanchoco (1989) and came up with an algorithm to solve layout design problem. The objective of this model is to minimize the total distance traveled. They reduce the problem size to be solved using a heuristic and the new reduced problem is used to determine the p/d points. Their heuristic determines the major flows into and out of each department and uses this as a base to prioritize the departments. It assumes that the flow data between departments is already known. Rectilinear distances are used and the flow is assumed to be between the departments centroids. It also uses the fact that in case of unidirectional AGV flow path design only four paths need be examined when considering the route between any pick up and drop off point. A linear programming model obtained after simplifying certain nonlinear terms is presented in this paper. For larger problem sizes this model may be difficult to solve.

Architecture's modules will contain sensor and actuator systems of a type relevant to the function of the module. Example modules may be Navigators, Manipulators, Vision Processing, etc. and each may contain any number of processor, sensor and actuator systems. The definition of a module is such that it must contain the following:

a) An interface to the bus.
b) The necessary logic to calculate all tasks assigned to that module.
c) The hardware for controlling all the input and output devices the module needs to perform its calculated tasks.
d) All the actual input and output devices needed by the module.